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that afterwards he seems quite exhausted, and sits very still until at length the fit comes on again, as it is sure to do in about ten seconds.

On the 26th of June, 1882, I found the nest and eggs, which I believe were previously unknown. The nest was by a willow bush in the damp meadow; it was apparently on the ground, but really raised six inches, being on the tangle of grass, etc. It was composed entirely of fine grass. The eggs—three in number—were of a delicate pink, with a few spots of brownish and of black towards the large end. The pink was lost on blowing them. One measured $.75 \times .50$ inches. Yet I must confess I did not shoot the birds at the nest; I only saw them a few yards off and heard their familiar *tweete*. So that there is possibility—though little probability—of error here.



ON THE FUNCTION OF THE INFERIOR LARYNX IN BIRDS.

BY J. M. W. KITCHEN, M. D.

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IN looking over the literature pertaining to the comparative anatomy and physiology of the vocal organs, we have repeatedly met certain statements which we think are incorrect physiological deductions, following the anatomical study that has been given to the vocal organs of Singing-birds. The great Cuvier was apparently one of the first scientists who gave this subject much study; and, with one exception, all subsequent writers whom we have read, whether French, German, or English, have substantially reiterated Cuvier's statements as to this matter. Indeed, there has been such unanimity of expression, and such similarity in the cuts shown in illustration of the subject, that one is induced to believe that Cuvier's exposition of the subject has been copied *in toto*, without personal investigation on the part of the writers.

The essential part of these statements is that the inferior larynx of birds, or syrinx as it is often called, is the principal agent employed in producing the tones of bird-song, and that the superior larynx is not a phonator, but only acts as a valve, preventing air and food from passing the laryngeal fissure. S. Messenger Bradley is the only writer whom we have read, who dissents from this deduction; and in this dissent we also take part. To be sure, our dissent is only a matter of opinion, and one that we are not prepared to substantiate by actual scientific proof, but it is an opinion that is the outcome of a very considerable study of the working of the human larynx, both in health and in disease, and one capable of considerable sustenance through analogous reasoning. It is an interesting subject on which more light is needed, and when one considers that the physiology of the human larynx is not yet fully understood, it will be conceded that there is a wide field still open for study of the vocal apparatus of birds. It is hoped that some one endowed with sufficient leisure and enthusiasm may take up the subject and pursue it to a successful issue.

The vocal mechanisms in man and bird differ very considerably, though there are analogous structures and functions in both animals. Birds have true voice, and even speech, though the speech of birds is very simple in character, and relates more to the *feelings* than to the *thoughts* of these creatures; but the so-called singing of birds is not song as rendered by man, who has no similar production of sounds, though an asthmatic wheeze produced in the bronchial tubes, and whistling with the tongue and teeth, or with the lips, approximate, in their mode of production, to the vocal efforts of the Song-birds. To thoroughly understand the subject, one must have a fair idea of the anatomy and physiology of the vocal apparatus in man.

It is presumed that the reader understands the ordinary laws pertaining to acoustics; that sound is the effect of air in peculiar vibratory motion upon the auditory apparatus; and that the character of vocal sounds as to pitch, intensity, timbre, etc., are due to the frequency and amplitude of the vibrations, and to the peculiarities of the structures that originate them as to shape, density, etc. The vocal sounds of man are produced by an apparatus that in gross, is substantially as follows: (1) A bellows or air propeller, consisting of the lungs, surrounded by the chest

walls at the sides, and by the diaphragm at the bottom. The muscular motion in these parts alters the shape of the chest, alternately enlarging its cavity and drawing air into the lungs; and then compressing those organs, driving out the air *via* the bronchial tubes, trachea, larynx, nasal passages, and mouth. (2) The phonating structure, which is the larynx, having a framework of cartilages known as the thyroid, the cricoid, and the two arytenoids; but whose essential parts are the two fibrous lips, or projections from the sides of the larynx, known as the vocal cords or ligaments, and the muscles that are attached to these ligaments and cartilages, for the purpose of rendering the former more or less tense, of drawing them apart, or of approximating their edges to various degrees, and of regulating their shape. The interposition of these vocal ligaments in various degrees of tension, approximation, etc., in the tract of the air-blast coming from the lungs, is the means of breaking up the air-column into the vibrations which produce the effect upon the ear known as vocal sounds. (3) The resounding cavities, which modify the sounds as to their power and other qualities. These cavities are the trachea and bronchial tubes, which reverberate the chest tones, and the throat, mouth, and nasal passages, which are instrumental in forming the head tones. The various positions and actions of these latter cavities and their contained parts, such as the tongue and soft palate, give the various effects of articulation to speech, as well as song. It must be noted that there is no dividing line between speech and song, the one gliding into the other, and that articulation is distinct from phonation. A whisper may be articulated speech, without sound being produced by the larynx.

This in brief being the structure of the human vocal apparatus, how does that of birds differ from it? (1) In the respiratory method, and in the structure of the respiratory mechanism. Almost the whole body of the bird is the air-bellows and reservoir. There is no diaphragm separating the chest cavity from the abdominal cavity, or at least it is very rudimentary, excepting in some birds like the Apteryx, where it is more nearly like that of mammals. Air passes through the bird's lung and out of it by numerous apertures on the pulmonary surface, to the various air cavities of the abdomen, neck, bones, etc. Here is a very large pneumatic storage cavity. In birds, the

expiration of air is effected by a decided muscular effort, drawing the largely developed breast-bone towards the spine, and this forces the air out of the body, while inspiration, or the drawing of air into the body, is the result of the resilient recoil of the breast-bone, and the rest of the tissues making up the chest walls. This action is just opposite to the respiratory method in man, where ordinary inspiration is effected by decided action on the part of the respiratory muscles, especially of the chief respiratory muscle, the diaphragm. This physiological peculiarity in birds gives them the ability to emit such powerfully loud and long-continued notes with little apparent effort. This is particularly to be noticed in small birds, such as the Canary and Black-poll Warbler. (2) The resounding cavities and articulating structures are very different from those in man. The trachea is a very much more distensible tube. Its rings are bony and complete. It is formed so as to be retracted or distended to a remarkable degree, through the action of the peculiar external tracheal muscles. This construction enables the organ to produce the effects of pitch or range in the notes of the musical scale, and also makes a good resounding medium, being in this respect analogous to an organ pipe. In the throat and mouth we find no soft palate, or pharyngeal vault, and hardly a trace of an epiglottis. Birds are very deficient in their powers of articulation, owing to the peculiarities of construction in the throat and mouth. The fleshy tongue of the Parrot gives that bird exceptional powers in this respect; but even the stiff, horny, and comparatively immobile tongue of other birds is capable, by its action, of producing the 'twittering,' 'whistling,' and other effects. The muscular flooring of the mouth, by its ability of contracting in a rapid fluttering manner, is very evidently capable of producing the 'warbling' effect. (3) The third and most marked deviation in birds from the vocal mechanism of man, is in the phonating or tone-producing structure. Instead of having one concentrated 'vocal box,' located at the top of the trachea, and which in itself contains all the parts necessary for regulating the pitch and some other qualities of the tone produced, birds have two larynges: the superior larynx being located as in man at the top of the trachea, while the inferior larynx or syrinx, is located at the inferior extremity of the trachea, at its point of bifurcation into the right and left bronchial tubes. This complex construction, that may be used for

vocal purposes, at first view seems very much like certain musical wind instruments. The true rima glottidis at the upper part of the windpipe simulating the outlet of the instrument, while the bronchial larynx is furnished with a peculiar tense membrane that looks as if it might perform the same duty as the reed in a clarionet. This is probably true in a certain degree, but no instrument has ever yet been able to imitate the best of bird-song.

The *superior larynx* is noted for its simplicity of construction and moderate functional action, in comparison with the larynx of man. As one examines it, the rigidity of the organ is conspicuous. Several of the upper tracheal rings are fused together and represent the human cricoid cartilage. Resting on this, forming the anterior part of the rim of the structure, is an oval or triangular thyroid cartilage. But at the rear of the organ, in place of the two pyramidal arytenoids, as in man, we find a large broad sesamoid plate running across the posterior wall, and on either side are two small cartilages connecting this plate with the thyroid, thus completing the circle of the laryngeal framework. The two arytenoids rest on top of this framework on either side, running well forward, and their inner margins form the rima glottidis, and this rim is the only substitute for the vocal cords of man. As we look inside of the organ we find no trace of those ligaments. The muscles of this structure are two. A surrounding sphincter muscle which closes the rim of the organ more or less tightly; and a pair of *thyreo-arytenoidei* which open the laryngeal fissure by drawing apart its rims. This fissure, in opening, is drawn furthest apart anteriorly, while in the human larynx the attachment of the vocal ligaments are close together in front, and they open widely at the back of the organ when the glottis is dilated during inspiration. Although this simple larynx has small functional ability, it is the point at which the true voice of birds is formed; especially the voice that is analogous to that of man; the voice that is peculiar to all the Clamatores. The Oscines are really not *singers* in the fullest sense of that word. Besides being able to break up the outgoing current of air into the vibrations which produce the rather coarse, harsh, and monotonous voice of the Clamatores, the rim of the glottis, in certain degrees of approximation, can produce the 'hiss' and a sort of 'whistle' similar to the

sound produced by the double concave, perforated tin mouth-piece of the children's toy that is frequently seen. This rim, by its vibrations when articulated by the highly developed tongue of the Parrot, produces the nearest approach to human singing of which birds are capable. Of course the much repeated ditty of a trained Polly is nearly destitute of variation in the pitch of the tones produced, any range in this respect being produced by differences in the strength of the air-blast, distension of the trachea, and change in shape of the mouth cavity. There is no muscular apparatus furnished for making any tension on the extremities of the rim of the glottis in birds.

The *inferior larynx*, or *syrinx*, is an organ peculiar to birds. Its parts are merely a different evolution and functional development and modification of the cartilaginous rings, mucous membrane, and muscular fibres seen in the trachea and bronchi of mammals. The structure varies widely in different birds, being most complex as a rule in the most able songsters. It may be highly developed in birds which are not ranked among the singers. This organ seems to have originally been called forth as a secondary valve, acting as an auxiliary to the superior larynx in closing the air passage leading to the lungs, during submersion of the heads of the aquatic birds. In most Ducks the lower larynx is expanded into an irregular bony case, divided into two unequal cavities. These cavities would undoubtedly add resonance to voice formed at the superior larynx. They would also act as a float, tending to make the upper part of the chest more buoyant. The inferior larynges in those birds examined by the writer are so constructed that some of the parts are very delicate, thin, and easily folded, thus enabling a closure of the air tract at this point to be easily accomplished, even by a simple recession of the neck. The bronchi are especially compressible and easily lacerated. They are strengthened by half-rings on the outer side, the inner being formed by a membrane that has been called the *membrana tympaniformis*. In most vocal birds the syrinx has a double glottis, one on either side of a bony bar, called the *os transversale*, which runs from before backward at the apex where the inner sides of the bronchi join. It supports a thin membrane which ascends into the trachea, and terminates in a thin, concave margin, called the *membrana semilunaris*. This is most developed in singing birds, and being vibratile forms an important part of their

'trilling' apparatus, the air passing to and from the lungs on each of its sides. Some of the outer bronchial half-rings are susceptible of a rotary motion on their axes, and are important agents in modifying the voice. Opposite the *os transversale*, on the outer sides of the bronchi, is a sort of fold of mucous membrane that presents a lip or projection something like the vocal ligament in the human larynx. There is one to each bronchus. This projection is probably formed by the process of the shutting up of the syrinx when the neck is retracted, and is really more the analogue of the ventricular fold in the mammalian larynx than of the vocal cord. There is no doubt but that this lip, when approximated to the 'cross-bone,' is capable of throwing the air current coming from the lungs into vocal, or rather sound vibrations. Every one has heard the 'squeak' that a fowl often emits when hopping about with its head cut off, and it is probable that the sound is produced by the syrinx. Several small muscles, varying in number from two to five, and which appertain to the lower larynx exclusively, coil around it, and enable it to make tense the tympaniform membrane, to close up the glotti, and to rotate its framework. An examination of the syrinx indicates that it undoubtedly may have an influence in the modification of the voice in its intensity, and in production of the 'trill.' The valve being shut, and the muscles of expiration being brought into play, a greater air pressure in the body can be brought to bear on the structures which throw the air-blast into vibration, and the gradual opening and shutting of this valve would give crescendo and decrescendo effects to the notes. It is even probable that some of the notes originate here, and are only modified on their way to the outer world through the upper air-passages, but this cannot be to so great a degree as is widely stated. The Blackbird has a curious 'querl' in its song, that seems as if it originates as deep down in the bird as this organ is located. We have spent many a spare moment observing the Blackbird in the Aviary at Central Park, trying to detect the exact location of the production of this sound. It is related that Cuvier cut the trachea across the neck at the middle, and even took away the upper part of the trachea in the Magpie, and yet, it is stated that the bird continued to cry as before the operation, the voice not being less strong or sharp. We should want to thirst for a knowledge of comparative physiology more than at present before repeating so cruel

an experiment; but we doubt the accuracy of this narration, and we should want to hear the subject of such an experiment really sing before believing that the syrinx is the seat of tone production. It would be enormously difficult to keep a bird alive after such an operation, to say nothing as to its regaining a condition of full health, or a condition in which it would feel like singing. A mere production of audible sound from the inferior larynx would not be accepted as the song tones of the bird. Man can produce a tone by the vibrations of the lips, but the vocal ligaments are the voice phonators for all that. The syrinx of a bird may be able to make a noise, but that does not prove that the superior larynx has nothing to do in the formation of the song of birds. However, we are open to conviction, and would gladly be set right by proof positive that our opinion as to this matter is wrong.

NOTES ON THE OCCURRENCE OF CERTAIN BIRDS IN THE MISSISSIPPI VALLEY.

BY W. W. COOKE.

DURING the progress of my studies of migration, I have been in correspondence with most of the active ornithologists in the Mississippi Valley. Among the notes they have contributed are some which seem worthy of being put on record. They may not all of them be first records for their section of country, but the occurrences are at places remote enough from the ordinary habitat to be worthy of note.

Hawk Owl in Northeastern Mississippi.—Among a list of birds occurring at Corinth, Miss., sent me by Dr. Rawlings Young, was the name of the Hawk Owl (*Surnia funerea*). Upon asking for the particulars of its capture, I received the following letter:—

“In reply to your question, I would say that I have never heard of but one being killed near here and that I shot myself. In 1882 I was shooting Quail over a brace of setters in thick sedge grass, three or four hundred yards from the timber, and while working up a scattered bevy the dogs pointed. Walking in, the Hawk Owl, much to my astonishment, got up from the grass, right under the dogs’ noses. As he went off I cut him down and had no trouble in identifying him from the cuts seen in Wilson.”